An analytical study of Kalmegh (*Andrographis paniculata*) and Kiratikta (*Swertia chirayita*): an economic substitution for metro cities in global pandemic with Healthcare 4.0

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Abstract: *Ayurveda* has always been a treasure of knowledge. During the COVID-19 pandemic when humans were forced to suffer and no cure seemed to exist to end suffering, the *Ayurvedic* medicine system once again proved its viability and brought our sufferings to the end. In this manuscript the core idea is to substantiate that the *Andrographis paniculata*, another indigenous herb, can be a well founded substitute for *Swertia chirayita*. In this work, authors

have made a comparative study between both drugs. For this, a systematic review of literature and a pharmacogonostical study was done. On investigation, both drugs are almost similar in qualitative phytochemical analysis, and qualities as par *Ayurvedic* pharmacology. It was also observed that most of the therapeutic actions of both drugs are similar. Graphical representation of the different parameters gives more insight to the readers. Use of pictures has also been done to heighten the interest of readers.

Keywords: *Swertia chirayita*; Kiratikta; *Andrographis paniculata*; Kalmegh; *Ayurveda*.

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Richa Singh is a graduate student majoring in BSc Agriculture. She has a keen interest in language and literature. Her hobbies are reading novels. She has great endearment for nature and wishes to do something to bring the torture we are doing to our environment to halt.

1 Introduction

1.1 Background

Along with the abundant erudition of medicines Ayurveda also provides to us vast fields for research purposes. *Kiratatikta,* i.e*., Swertia chirayita* found in the Himalayan regions had been frequently described in the *Ayurvedic* literature (Vaidya, 2018) because of it is unique viability as a medicinal herb. On the other hand, *Andrographis paniculata* commonly known as *Kalmegh* is found in the plain regions of the Indian subcontinent. The respective drug had been used therapeutically for ages by the indigenous people of Asian and European countries (Hossain et al., 2014).

Swertia Chirayita (Kiratatikta) and *Andrographis paniculata* (*Kalmegha*) both are widely used herbs with high medicinal value. These are being used by *Ayurvedic* physicians in different diseases, such as (*Jvara*) fever, (*Krimi*) worm infestation, (*Vrana*) wound, and (Kushtha) skin diseases (Sastri, 2012). Modern studies have also explicitly revealed that both these herbs have a wide range of pharmacological actions such as antipyretic, antimalarial, anti-inflammatory, antidiarrhoeal, antiviral, hepatoprotective, antidiabetic, anticancer, anti-human immunodeficiency virus (HIV), and immune stimulator (Sehgal et al., 2018; Schimmer, 1996).

Sudarshan Ghan Vati and AYUSH-64 which were found very effective in COVID-19 treatment are famous formulations of *S. chirayita*. Recently *A. paniculata* also has been very popular among pharmaceuticals. During the pandemic, it has been found effective in the treatment of COVID-19 (Banerjee et al., 2021).

The aim of this work is to compare both the drugs through literary review and pharmacogonostical analysis so that we can assess whether *A. Paniculata* can be used as a substituent drug to *S. Chirayita* or not. Because *S. Chirayita* is not only very costly but also an endangered species making its availability harder for common use. On the other hand, *Kalmegh*, i.e., *A. Paniculata* not only is cheap and cost-effective but can also be grown anywhere easily just like a weed making it much more feasible. A detailed study is provided in the manuscript, describing elaborate analysis.

1.2 Organisation of the paper

This study, first of all, gives a general idea of global health in today's time and the adverse effects of modern medicine to manage COVID-19 pandemic. The author team explained about Ayurveda and its holistic approach. For the endorsement of the study, the author team initially did a literary survey and reviewed research papers of concerned drugs and various Ayurvedic texts like *Charak Samhita, Sushruta Samhita, Ashtang Samgrah, Raj Nighantu, Bhavprakash nighantu, Dhanvantari Nighantu, Priya nighantu, Adarsh nighantu, Dravyaguna Vigyan,* etc. This literary survey provides deep knowledge about both drugs i.e. *Kiratatikta* and *Kalmegha*.

The author team has described the methodology in which they have represented the methods used for the study. This study has been divided into two sections, the first was a literature review and the second was a pharmacogonostical screening of both plant samples. After critical analysis of pharmacognostical screening results were presented. The manuscript presents all data in graphical and tabular form as well.

In the recommendation section, which is one of the most important parts of the research studies, suggestions for specific interventions to address the issues and constraints identified in the assessment have been presented. The novelty section refers to elements that are new in the research. In the last, the conclusion section represents the final assessment and describes the overall findings of the study.

1.3 Motivation of the study

In the terrifying time of COVID pandemic, when the whole of humankind was looking for a miracle, *Ayurveda* proved to be a boon for our survival. Formulations like *Sudarshan Ghan Vati* and AYUSH-64, gave positive results against COVID-19. The main ingredient of this formulation is *Kiratatikta,* i.e., *S. Chirayita*. The main motivation of this study is to find an economical substitute for *S. Chirayita* and as well as preservation of *S. chirayita*, as it is a critically endangered medicinal herb now (Bentley and Trimen, 1880; Hooker, 1885).

1.4 Scope of the study

The study shows the uprightness of indeginous knowledge of medicines. It also encourages us to dwell deeper in the ocean of natural herbs and traditional medicinal systems. This study will provide us a better replacement for *Chirayta* as it is an endangered herb. Also it opens up the gates for the discovery and development of more such drugs which need to be authenticated as substitutes for the traditional drugs which now are on the verge of extinction. Ethically it will lead to reduced consumption of *Kiratatikta* by us humans, prolonging it is extinction hopefully for forever.

1.5 Role of authors

Dr. Bhavna Singh acted as team leader and coordinated among all co-authors. She prepared the topic introduction and background study; also contributed to experiments. Rohit Rastogi prepared the structure of the manuscript and ensured the quality of the content along with all co-authors. Dr. Lalit Raj Singh and Dr. Ankur Singhal did the

experimental Analysis and along with concluding remarks. Ms. Richa Singh has compiled the literature survey along with graphical representations.

1.6 Ethical certification

The experiments do not include any human related experiments and no ethical violation has been made. Though the authors performed lab experiments with a comparative analytical study of two herbs, i.e., *S. chirayita* and *Andrographis paniculata*, it does not violate any health related measures.

1.7 present crisis of pandemic and Indian ecosystem

The COVID-19 pandemic has created a disturbance for the global healthcare system. Health organisations and institutions fighting infectious disease, supporting health workers, delivering social services, and protecting livelihoods have captured the world's attention. Due to this pandemic challenges of access, safety, supply chain logistics and financial stress were faced by everyone like never before. The short-term implications of this global challenge are evident everywhere, but the long term consequences of the pandemic, how it will affect health and development institutions, government policies, occupations, and priorities are still difficult to imagine (Perera, 2021).

As modern science is evidence based science and depends upon authentic research, it is difficult to develop treatment protocol for COVID-19 in such a short duration and without proper authentic research which takes its stipulated time. In the case of conventional medicine, this inevitable dilemma between medical research and clinical medicine has been resolved by the parallel development of the pragmatic standard of care guidelines for clinical practice while at the same time pursuing rigorous research protocols to generate higher levels of evidence.

1.8 Global scenario of healthcare

Today Global health depends upon 6 major issues- Pandemics, environmental factors, economic disparities, political factors, non-communicable disease and animal health food sourcing and supply. And there are three challenges i.e. building medical capacity, increasing access to medicines and improving medical information (Macpherson, 2021).

There is a need for a holistic approach. Focus should be targeted at changing lifestyles so that everyone can live a healthier life. Healthcare leaders worldwide can adopt 3 major initiatives. First one is Intervene at the intersection of health and lifestyle, second one is Transition from volume to value and the last one is Interoperability in the digital age. Basic need is the power of integration which can easily help to eradicate major health issues all over the world and turn our planet into a healthy one (Broussard, 2018).

1.9 Allopathic medicine and their side effects

There are a variety of modern medicines available to fight the germs in different ways, either to kill it or to stop its production. But neither of the treatments focuses on prevention, and treatment is always disease specific not patient oriented i.e. it focuses on the part, not complete health. So, allopathic treatment is not having a holistic approach to

treat something in the best way. The disease might appear again, leading to expenses of both money and time (Mandel, 2009; Singh and Singh, 2020).

1.10 Indian vedic life style and science of ayurveda

Ayurveda is an age-old science, comes from the ancient Vedic tradition of India. It is known as the *upveda* of the *Atharva Veda*. It is understood as the science of life. It is a study of life based on the direct experience of the *Ayurveda Siddhant*, i.e., fundamental 'laws of nature' that govern our world and that cannot be challenged. *Ayurveda* basically deals with areas such as *Dravya* (herbs), *Ahara* (diet), *Vyayama* (exercise), *Prakriti* (individual constitutions) and most important are *Yoga* and *Swasthwritt* (Preventive social medicine). So treatment with a holistic approach is possible through *Ayurveda* only (Britannica, 2019).

1.11 Medicinal plants and their boons

The medicinal plants are the spine of the Indian system of medicine i.e. *Ayurveda, Siddha, Unani*, and ethno-medicines as well. Herbal medicines are the key factors of primary healthcare due to their availability, compatibility and affordability. About 80% of the world's population depends largely on traditional remedies for their healthcare needs. With emerging awareness towards *Ayurveda* and herbal medicine, use of medicinal plants is anticipated to rise globally. At present, approximately 70,000 to 80,000 medicinal plant species are used globally (Chaudhari and Singh, 2016). *Ayurvedic* classics have described many efficacious herbs for treating a variety of ailments. *Swertia chirayita* (*Kirattikta*) is one of them. *Andrographis paniculata* (*Kalmegha*) is also a widely used potential herb with high medicinal value. The objective of this research work is to critically analyse the properties of *Kiratatikta* and *Kalamegha*.

1.12 Kalmegh (Andrographis paniculata)

Andrographis paniculata (Burm. f.)Wall.ex Nees belongs to the family Acanthaceae commonly known as King of Bitters. It is used for centuries in Asia as ethnomedicine for the treatment of various ailments such as dyspepsia, diarrhea, dysentery, influenza, respiratory infections, malaria, and is used as an antidote for snake-bite and poisonous stings of some insects (Chopra, 1980). This herb is used by the tribals of Tamilnadu, India, to treat different diseases like dysmenorrhoea, leucorrhoea, prenatal and postnatal care, intestinal worm infestation, eczema, leucoderma, malaria, jaundice, gonorrhea, and general disorders like wounds, cuts, boils, and skin diseases (Alagesaboopathi et al., 1999). In Malaysia, its decoction is used to treat cancer, hypertension, diabetes, malaria, common cold, and snakebite. In traditional Chinese medicine, it is seen as the cold-property herb used to rid of the body heat and fever and to expel toxins from the body (Okhuarobo et al., 2014). In *Ayurveda, Kalmegh* is indicated especially in liver disorders and fever, skin disease, intestinal worm infestation as well. *A. paniculata* is an important constituent of at least 26 formulas in Indian pharmacopeia and described in American and British pharmacopoeias as well. (Sehgal et al., 2018).

1.13 Kiratatikta (Swertia chirayita)

S. Chirayita, commonly known as '*Chirayta*' belongs to the family of Gentianaceae is an important plant for various herbal remedies. It is very commonly used by local people as a remedy for various disorders like hepatitis, fever, vomiting, and indigestion. Decoction of *Chirayta* is used traditionally, as hepatoprotective, anthelmintic, antimalarial, antifungal, antibacterial, cardiac stimulant, anti-fatigue, anti-inflammatory, anti-aging, and antidiarrheal. It is beneficial for the vital organs like liver and heart, it lowers blood sugar and blood pressure as well (Schimmer and Mauthner, 1996). *Ayurveda* medicine system state extensive range of indications of *Kiratatikta* like chronic fever, malaria, anemia, bronchial asthma, liver disorder, dyspepsia, gastritis, ulcers, constipation, skin diseases, intestinal worms, epilepsy, and certain types of mental disorders, and *Prameha* (diabetes) (Sharma, 2013). It increases secretions of bile and purifies blood. Herbal formulations such as Ayush-64, Sudarshan churna, Sudarshan ghan vati, Mensturyl syrup, Diabecon, and ointment Melicon V contain *S. chirayita* extract. (Dinda, 2019). *S. Chirayita* is mentioned in American and British pharmacopeias in the forms of infusions and tinctures. It is extract shows a wide range of pharmacological activities, such as antimicrobial, anti-neoplastic, anti-diabetic, antioxidant, and anti-inflammatory activities (Joshi and Dhawan, 2005).

2 Literature review

S. chirayita is a well known medicinal plant which is now among the list of endangered species. Mostly it is distributed in the region lying between Kashmir and Bhutan. Kumar and Staden (2016) emphasised *Swertia chirayita's* therapeutic potential in liver diseases, malaria, and diabetes as well as the importance of implementing comprehensive conservation strategies because it is on the edge of extinction. It is found in temperate climate; in India it is found in Himalayan regions at the altitude of 1200–2100 m. Although the entire plant of *S. Chirayita* is used for healing, the roots are the most widely used part of the plant. Various approaches may be adopted for conservation of plants such as micro-propagation, production of synthetic seeds, and hairy root culture. The plant has been cited in several classical and modern texts including *Ayurveda, Unani, Siddha*, British Pharmacopoeia, American Pharmacopoeia and Indian Pharmaceutical Codex. It was also urged that replacement medications with similar pharmacological and phytochemical actions be sought.

Lwin Lwin Nyein and his team explored how globally it has been realised that it is important to study medicinal plants for new drug discovery and development. The scientific validation of traditional medicines has given a new concept of reverse pharmacology. Nyein and his team was worked on *S. Chirayita* to study its antimicrobial activity with microbial agents such as *Staphylococcus Aureus* and *Bacillus cereus* for gram positive bacteria and *Escherichia coli* and *Salmonella Arisonae* for gram negative bacteria. Antimicrobial activity was studied with a disc diffusion method. It was concluded that ethanolic extract of leaves and stem of *S. Chirayita* has antibacterial properties. (Nyein et al., 2013).

A. paniculata commonly found as weed is another very important indeginous medical plant that has been used for years by the Asian and European countries. (Aleem nd Kabir, 2018). It grows mostly in tropical and moist regions and is distributed in the plains of

India, Pakistan, Sri Lanka and the West Indies. It is a small terrestrial, annual, erect herb, attaining 1–3 feet of height. The Stem is dark-green, much branched, sharply quadrangular and smooth from the lower part with longitudinal furrows. The plants bear flowers and fruits during the months of April-May and September-October (Sehgal et al., 2018; Hossain et al., 2014).

A. Paniculata contains various compounds, terpenoids (Diterpenoid lactones), flavonoids (flavones), xanthones, polyphenols, trace elements (Cr, Mn, Co, Ni, Zn, Cu, Se, Rb, Sr, and Pb), and macro-element (potassium and calcium). Andrographolide is the commonest terpenoid isolated from *A. Paniculata*, most prominently on account of its therapeutic activity. Cinnamic acid, caffeic acid, ferulic acid and chlorogenic acid were also isolated (Okhuarobo et al., 2014; Kulyal et al., 2010). Several studies has been reported that *A. Paniculata* showed a broad range of pharmacological effects including immunostimulant, anticancer, anti-microbial, cytotoxic, antimalarial, anti-inflammatory, anti-oxidant, anti-diabetic, anti-infective, anti-angiogenic, hepato-renal protective, sex hormone modulatory, liver enzymes modulatory, anti-HIV and insecticidal and toxicity activities (Sehgal et al., 2018).

Hossain and team have tried to bring to light the effectiveness of plant *Andrographis paniculata* also known as the king of bitters. The plant which is indigenous to Asia has been a part of various indigenous medicine systems since a long time especially in European and Asian countries. *A. Paniculata* has anti cancer, antiviral, anti hyperglycaemic, antioxidant,anti hepatitis,and cardiovascular effects. The plant can be grown even under abiotic stress. All parts of the plant are effective. The plant is also a very good blood purifier, in terms of Ayurveda it can be described as *Pittashamak* (Hossain et al., 2014).

Chaturvedi and his team discussed that *Kalmegh* which usually grows as a weed has hidden potentials and is a very efficient hepatoprotective agent. Chopra and Nadkarni have mentioned the effectiveness of *Kalmegh* decoction. *Kalmegh* also increases biliary flow. Later on other authors reported the presence of two non-basic principles from the leaves of *a. Paniculata*, besides an essential oil and named them as Andrographolide CH_2O; M.P. 206) and Kalmeghin (CH_2O; M.P. 185°). It shows a significant increase in serum protein level. The plant is a cheaper and beneficial treatment for hepatitis and may prove a valuable contribution for treatment of liver disorders (Chaturvedi et al., 1983).

2.1 In respect to Ayurveda

In, *Ayurveda*, pharmacological actions of any drugs are based on their *Rasa panchaka* (properties and actions) i.e. *Rasa* (Taste), *Guna* (physical property), *Virya* (potency), *Vipaka* (post metabolism test) and *karma* (therapeutic action). According to Ayurvedic Pharmacopeia of India, the properties and actions of *Kalmegha* and *Kiratatikta* are listed in (Pl. refer Table 1). We found all the properties are similar except for their potency and some difference in their actions (API, part 1, vol. 1, 2001; API, part 1, vol. 8, 2008)[34-35]. Most of the actions and uses of both the drugs are similar as presented (Pl. refer Table 2) (Sharma, 2013). In ‘Pharmacognosy of Ayurvedic drugs of Travancore, the cochine’’ *Andrographis paniculata* is described for *Kiratatikta*.

Table 1 Properties and action Kiratatikta (*Swertia chirayita*) and Kalmegha (*Andrographis paniculata*)

Rasa-panchaka (properties and action)	*Kiratatikta (Swertia chirayita) (API, 2001; Pandey, 2013)*	*Kalamegha (Andrographis paniculata) (API, 2008)*
Rasa (taste)	Tikta (Bitter)	Tikta (Bitter)
Guna(qualities)	*Laghu* (Light for digestion), *Ruksa* (Dry in nature)	Laghu (Light for digestion), Ruksa (Dry in nature)
Vipaka (post metabolic property)	*Katu* (Catabolic Property)	Katu (Catabolic Property)
Virya (potency)	*Sheeta* (Hot)	Ushna (Hot)
Karma (pharmacological actions)	Kapha-pitta-hara (alleviate *kapha* and *pitta* humour), Jvaraghna (antipyretic), *Deepan* (appetiser), *Anuloman* (carminative), *Krimigan* (wormicidal), *yakrit uttejak* (stimulates liver), *Shothahar* (anti-inflmmatory), *Raktashodhak* (purifies blood), *Vrana shodhaka* (wound cleanser)	*Kapha-pitta-hara* (alleviate *kapha* and *pitta* humour), *Jvaraghna* (antipyretic), *Deepan* (appetiser), *Anuloman* (carminative), *Krimigan* (wormicidal), *yakrit uttejak* (stimulates liver), *Shothahar* (anti-inflmmatory), *Raktashodhak* (purifies blood),

Table 2 Medicinal uses of Kiratatikta (*Swertia chirayita*) and Kalmegha (*Andrographis paniculata*) in Ayurvedic texts

Kalmegha (Andrographis paniculata) (Sharma, 2013)	*Kiratatikta (Swertia chirayita)(Sharma, 2013)*
Krimi rog (Worm infestation)	*Krimi rog* (Worm infestation)
Kushtha rog (Leprosy)	*Kushtha* (Leprosy)
Yakritvikar (Liver disorders)	*Yakritvikar* (Liver disorders)
Jwara (Fever)	*Jwara* (Fever)
Shotha (Inflammation)	*Shotha* (Inflammation)
Rakta vikar (Bleeding disorders)	*Rakta vicar*
Vibandh (Constipation)	*Vibandh,*
Agnimandya (Poor digestion)	*Agnimandya*
Tvaka vikara (Skin disorders)	*Tvaka vikara* (Skin disorders)
Vrana (wound)	*Raktapitta* (hemorrhagic disorders), *Kasa* (cough), *Svasa* (asthma), *Trishna* (thirst), *Vrana* (wound)

2.2 Ethno-medicinal uses (Pl. refer Table 3)

Kalmegh is used commonly by the ethnics of Kerala, Tamilnadu, and other southern parts of India while *Kiratatikta* is used in Uttarakhand, Sikkim and other Himalayan regions for similar therapeutic uses. The preference for one drug over the other is based on their availability in a particular region.

Table 3 Ethno-Medicinal uses of Kiratatikta (*Swertia chirayita*) and Kalamegha (*Andrographis paniculata*)

Kiratatikta (Swertia chirayita) (Kumar, 2016; Pandey, 2013)	*Kalamegha (Andrographis paniculata) (Okhuarobo et al., 2014)*
Hepatic disorders; GIT disorders (indigestion, dyspepsia intestinal worms and,diarrhea)	Dyspepsia, dysentery, stomachic and diarrhea anthelmintic, hepatitis, and irregular stools
Tonic for boosting immunity, cough, rhinitis, viral fever, and dyspnoea	Tonic, Febrifuge, influenza, and respiratory infections, fever, loss of appetite, common cold, cough, fever, sores and also bronchitis .
Headaches and blood pressure, malaria	Hypertension, and malaria
Renal infection, UTI, GIT infections, nausea, gastric ulcers, and hiccups	Gastro-intestinal disorder, colic pain, urinary tract infection
Effective against scorpion bite	Snakebite and insect sting
Used in excessive vaginal discharge, eczema and pimples	Tuberculosis, mouth ulcers, diabetes, cancer

Table 4 Comparative study of pharmacological actions of Kiratatikta (Swertia chirayita) and Kalmegha (*Andrographis paniculata*)

Kiratatikta (Swertia chirayita) (Kumar, 2016)	*Kalamegha (Andrographis paniculata)(Jaykumar et al., 2013)*
Antibacterial	Antibacterial
Antifungal	-----
Antileishmanial	-----
Antihelminthic	-----
Antimalarial	Antimalarial
Egg hatchability and larvicidal	
Larvicidal and ovicidal effects	
Anti-hepatitis B virus	
Anti Inflammatory	
Anti-inflammatory effects	
Hypoglycemic, Antidiabetic	
Antihyperglycemic activity	
Antipyretic, Analgesic	Analgesic, antipyretic
Anticarcinogenic	Anticarcinogenic
Hepatoprotective	Hepatoprotective
Antiviral	Antiviral
Anti-HIV effect	Anti-HIV effect
Antioxidant activity	Antioxidant activity and immunomodulatory effect

2.3 Pharmacological actions (Pl. refer Table 4)

On reviewing several research papers we have found that both the drugs *A. paniculata* and *Swertia chirayita* are very important medicines. Both of these drugs perform various pharmacological actions such as antimicrobial, anti-malarial, anti-inflammatory,

anti-oxidant, immune-stimulant, anti-diabetic, anti-angiogenic, hepato-renal protective, and anti-toxic (Sehgal et al., 2018).

3 Experimental study and methods used

3.1 Methods

For the entire study of both the drugs, i.e., *S. chirayita and A. paniculata*, various aspects were considered. First of all, the team did a critical review of ancient literature along with modern literature. Data compiled and presented here were obtained through A*yurvedic* texts like *Chikitsa and Samhita Granthas, Nighantus*, and other authentic books, E-resources like Science Direct, Pubmed, Google, and research papers up to September 2021.

Secondly analytical study has been done in the laboratory for organoleptic, physicochemical and phytochemical analysis. Samples were collected from their native place of plants. The samples of *Kiratatikta* were collected from high hills of Dhanolti and *Kalamegha* from Dev Samskriti Vishwavidyalaya, Shantikunj, Haridwar, Uttarakhand. Collected samples of both herbs were kept for drying by keeping them between the folds of old newspapers. The dried specimens were then pasted on the herbarium sheets of standard size and proper labeling was done and was certified from Botanical Survey of India, Dehradun.

3.1.1 Organoleptic Study(Pl. refer to Table 5)

All the collected samples were dried and powdered for further study. The powdered sample of both drugs observed with naked eye and magnifying lens, to analyse different organoleptic features i.e. colour, odour, taste, and appearance were recorded (The Ayurvedic pharmacopoeia of India, 2001).

3.1.2 Determination of pH value

The pH value of an aqueous liquid may be defined as the common logarithm of the reciprocal of the hydrogen ion concentration expressed in grams per litre, The pH of both samples was measured by using a digital pH metre.

3.1.3 Determination of different soluble extract

5 g coarse powder of sample drug macerated with 100 ml solvent, shaking frequently for six hours and allowed to stand for eighteen hours after that it was filtered, filtrate kept to dry in a tarred flat bottomed shallow dish. The percentage of solvent-soluble extract with reference to the drugs which are already dried in air is calculated. Determination of extract in different solvent like Aqueous, alcohol and Petroleum Ether was done in the same manner as mentioned above.

3.1.4 Determination of total ash

Total amount of material remaining after ignition is measured through the total ash method. Both physiological ash which is derived from the plant tissue itself and non-

physiological ash which is the residue of the extraneous matter (e.g., sand and soil) adhering to the plant surface are measured during the process. Silica Crucible was cleaned, dried well, labelled with glass pencils and then weighed to constant weight. 5 gm of powdered drug sample put in the Silica crucible. The drug was spread evenly into a thin layer. This crucible was placed in a muffle furnace and ignited at a temperature of 450°C for about six hrs or more until the ash was totally free from carbon. The crucible containing the ash was allowed to be cooled in desiccators and subsequently weighed to constant weight. Calculation of ash with reference to the drug (which must be air dried) is performed.

3.1.5 Determination of acid insoluble ash

Acid insoluble Ash value was determined as per Ayurvedic Pharmacopoeia of India, 2008. Boiled the total ash, with 25 ml of 2 M hydrochloric acid for five minutes, collected the insoluble matter in a Gooch crucible or on an ashless filter paper, washed with hot water, ignited, cool in a desiccator and weighed. Calculated the percentage of acid – insoluble ash with reference to the air – dried drug.

3.1.6 Water-soluble ash

Water – soluble ash value determined as per Ayurvedic Pharmacopoeia of India, 2008. Boiled the total ash for five minutes with 25 ml of water; collected the insoluble matter in a Gooch's Crucible or on an ash less filter paper, washed with hot water and ignited for 15 minutes at a temperature not exceeding 450 C. It was subtracted (insoluble matter) from the weight of the ash; the difference in weight represented the water-soluble ash.

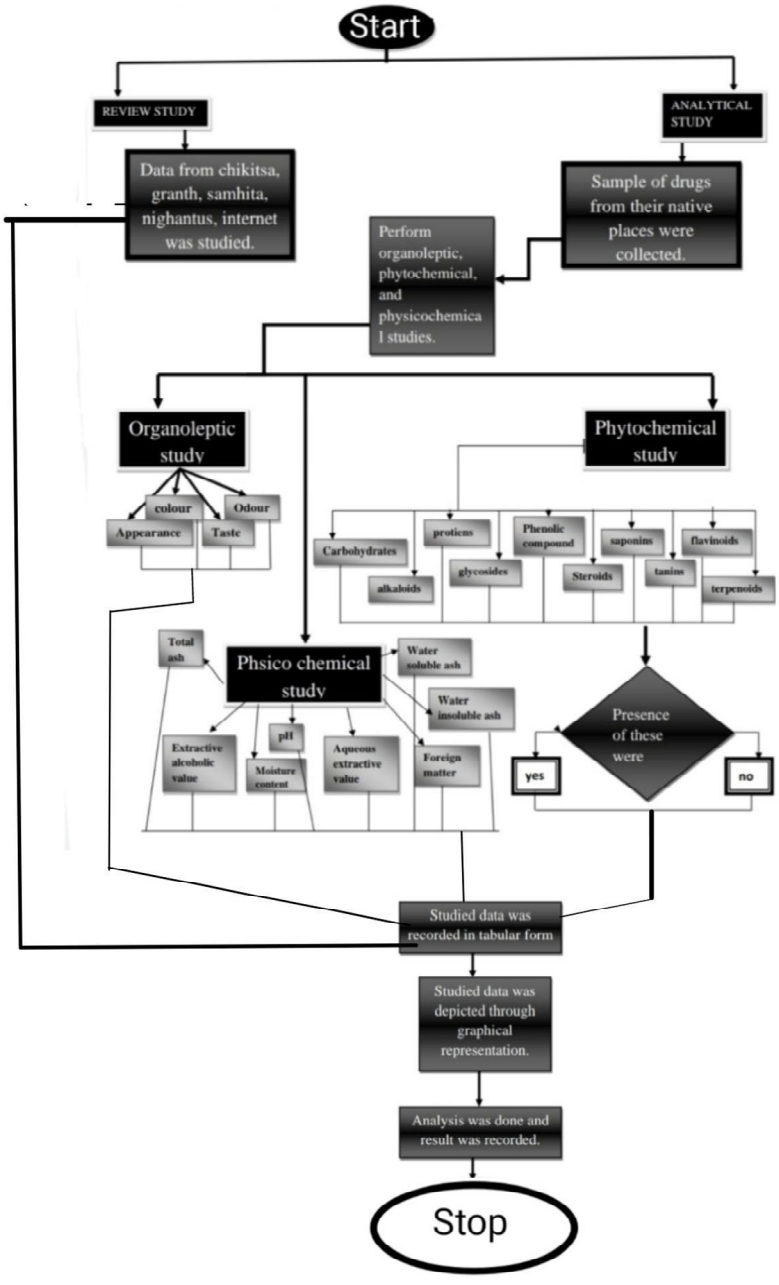
3.1.7 Phytochemical study

Freshly prepared extracts of both sample drugs were used for different tests to know the availability of different active phytochemicals as follows: Fehling solution test for Carbohydrates, Mayer reagent test for alkaloids, Biuret Test for amino acids and proteins, Foam test for saponins, Borntragor's test for glycosides, Phenolic Test for phenolic compounds, Salkowaski test for steroids, FeCl3 test for Tannins, Iodine test for starch, test for flavonoid, test for terpenoids.

3.2 Component collection data

- Collection of samples – The samples of *Kiratatikta* were collected from high hills of Dhanolti and *Kalmegha* from Dev Sanskriti Vishwavidyalaya, Shantikunj, Haridwar, Uttrakhand. The specimen of *Kalmegha* was collected in the last of September and *Kiratatikta* was in the mid of September.
- Other materials: Magnifying lens, measuring tape for organoleptic study. Eosin, Ferric chloride, Naphthol, Iodine, Sudan red 3 and Ethanol. All the analytical procedures were done in Pharmacognosy labs of GS Ayurveda Medical College.

Figure 1 Flow chart of experimental analysis and process description



The flowchart briefly depicts the methodology of our research work which was broadly divided into two parts, i.e., review study and analytical study. In the analytical study reviewing organoleptic features, physical parameters, and the phytochemicals of both drugs samples. Later study reviews the presence of ten Phytochemicals in different extracts of both the drugs. Physico-chemical study then calculates the value of the

respective parameters on the basis of which comparative study between the two drugs is performed (Pl. refer Figure 1).

4 Results and discussion

4.1 Organoleptic analysis(Pl. refer Table 5)

On the basis of organoleptic analysis we find not much differences between *A. Paniculata* and *S. Chirayita*; there is difference found only in their colour, as organoleptic features of both samples are given below in tabular form (Pl. refer Table 5).

Table 5 Organoleptic characteristics of both the medicinal herbs under study.

Characters	*Swertia Chirayita*	*Andrographis paniculata*
Appearance	Crude drug	Crude drug
Colour	Yellowish brown	Green
Odour	Characteristic	Characteristic
Taste	Bitter	Bitter

4.2 Physicochemical analysis

1 Moisture content of both the samples was determined and it was found to be least in *Kalamegha*, i.e., 8.70% while highest in sample of Kiratatikta, i.e., 9.52%.

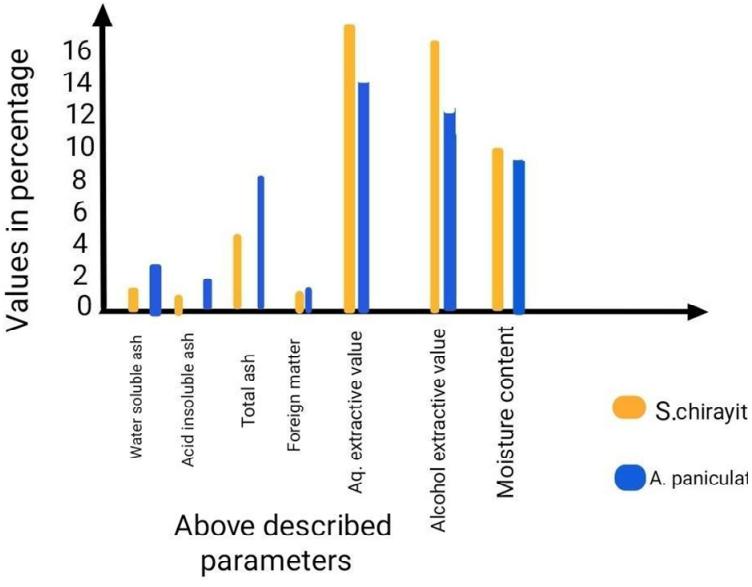
2 Total ash content was found to be 5.19% in the sample of *Kiratatikta* and in the sample of Kalamegha is 8.62%. Acid insoluble ash was found to be lower in the sample of Kiratatikta 0.98% than in the sample of Kalamegha 1.72%. Water soluble Ash was also found lower in samples of Kiratatikta 1.24% than in samples of Kalamegha 3.42%.

3 It was observed that values of alcohol soluble extract and water soluble extract were higher in samples of Kiratatikta, i.e., respectively, 15.15% and 15.98% and found to be least in Kalamegha respectively 10.76% and 13.55%.

Table 6 Comparative physicochemical study of *Swertia chirayita* and *Andrographis paniculata*

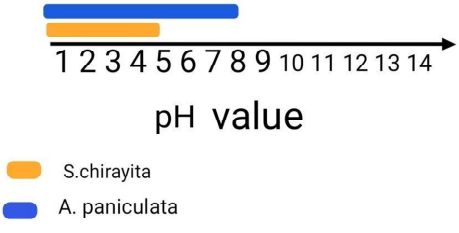
S. no.	*Features*	*Andrographis paniculata*	*Swertia chirayita*
1	Moisture content	Moisture content 8.70% w/w	Moisture content 9.52% w/w
2	pH	7.97	4.64
3	Alcohol extractive value	10.76% w/w	15.15% w/w
4	Aqueous extractive value	13.55% w/w	15.98% w/w
5	Foreign matter	1.34% w/w	0.95% w/w
6	Total ash	8.62% w/w	5.19% w/w
7	Acid insoluble ash	1.72% w/w	0.98% w/w
8	Water soluble ash	3.42% w/w	1.24% w/w

Figure 2 Graphical bar chart for comparative analysis of physico-chemical properties of *Andrographis paniculata* and *Swertia chirayita* (see online version for colours)



Here the blue bars give the values of A. paniculata and the yellow one show the data of S.chirayita. Here we can clearly see that except for the pH, total ash and acid insoluble ash the other values do not vary much. The difference in pH can be overcome by taking complementary drugs with desirable pH. Overall the study shows that A. paniculata can be a very good substitute for S. chirayita (Pl. refer Figure 2 and Figure 3).

Figure 3 Comparison of *Andrographis paniculata* and *Swertia chirayita* on ph-scale (see online version for colours)



Total ash, water soluble ash, and acid insoluble ash were found higher in *Andrographis paniculata* in comparison to *Swertia chirayita*, indicating that the *Andrographis paniculata* contains more minerals. The presence of polar chemicals in *Swertia chirayita* indicates its greater alcohol and aqueous extractive values.

4.3 Qualitative phytochemical analysis

4.3.1 Phytochemical study

Freshly prepared extracts of both sample drugs were used for different tests to know the availability of different active phytochemicals as follows.

A Carbohydrates: Fehling solution test showed the presence of carbohydrates in aqueous extract but not in alcohol extract and in petroleum ether extract.

B Alkaloid: In both samples, Mayer reagent test showed the presence of alkaloids in all extract, i.e., aqueous, alcoholic and petroleum ether.

C Amino acids: Biuret Test showed the presence of amino acids in aqueous extract but not in Alcoholic and Petroleum ether extract of *Kiratatikta* and *Kalamegha*.

D Proteins: In both the samples, Biuret Test showed the presence of proteins in aqueous extract but not in Alcoholic extract and petroleum ether extract.

E Saponin: In both the samples, Foam test showed the presence of saponins in Aqueous extract and in alcoholic extract but not in petroleum ether extract.

F Glycosides: In both the sample, Borntragor's Test showed presence of glycosides in the aqueous extract but not in Alcoholic and petroleum ether extracts.

G Phenolic Compounds: In sample of *Kalamegha*, Phenolic Test showed presence of phenolic compounds in aqueous and alcohol extracts but not in petroleum ether extracts while in sample of *Kiratatikta*, it showed presence of phenolic compounds in alcoholic extract but absent in petroleum ether and aqueous extract.

H Test for Steroids: In both the samples, Salkowaski test showed the presence of steroids in all extracts, i.e., in aqueous, petroleum ether and in alcoholic extract.

I Test for Tannins: In *Kalamegha* sample, FeCl3 test showed presence of Tannins in aqueous extract and in alcoholic extract but absent in petroleum ether extract while in sample of *Kiratatikta*, it showed presence of Tannins in alcoholic extract but absent in aqueous extract and petroleum ether extract.

J Test for Starch: In both the samples, Iodine test showed presence of starch in the aqueous extract but absent in alcoholic and petroleum ether extracts.

K Test for Flavonoid: In both the samples, presence of flavonoids in all extracts, i.e., aqueous extract, petroleum ether extract and alcoholic extract.

L Test for Terpenoids: In both the samples, Terpenoids test showed the presence of Terpenoids in alcoholic extract and petroleum ether extract but absent in Aqueous extract (The Ayurvedic Pharmacopoeia of India, 2008) (Pl. refer Table 7).

The above figure represents the comparison of respective phytochemicals present in the Aqueous medium for *A. paniculata* and *S. chirayita*. All the major phytochemicals are common between *A. paniculata* and *S. chirayita* except for the absence of phenolic compounds in *S. chirayita* and absence of terpenoids in both the plants (Pl. refer Figure 4).

Figure 4 Graphical representation of phytochemical analysis in aqueous extract of a. paniculata and s. chirayita (see online version for colours)

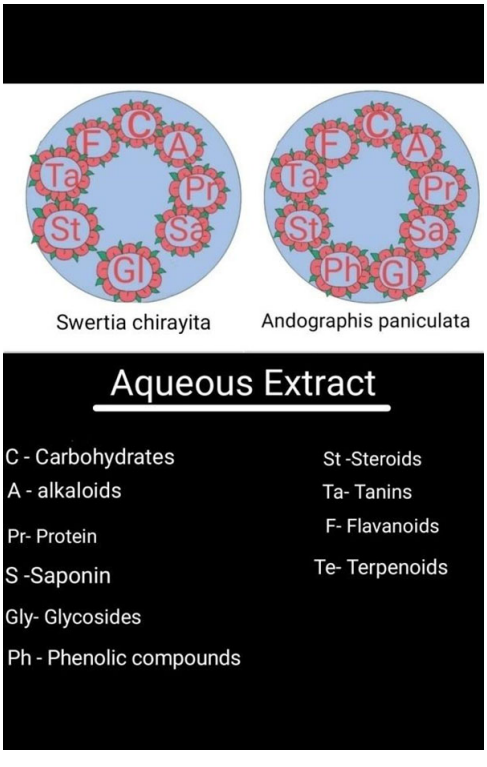
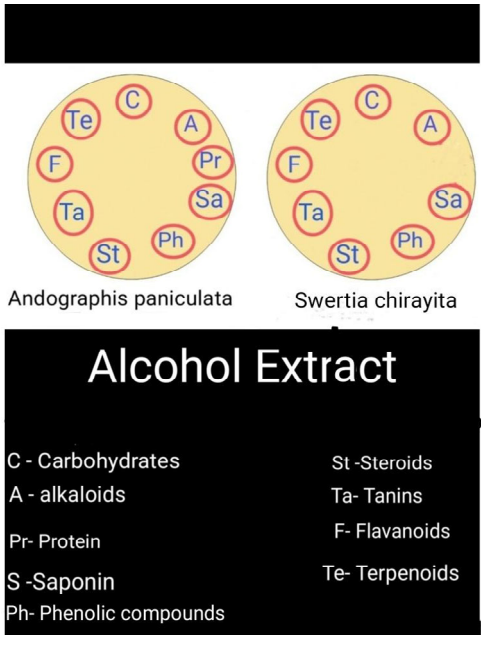


Table 7 Comparative study of phytochemicals present in different extracts (Aqueous, Alcohol, Petroleum ether) of *Swertia chirayita* and *Andrographis paniculata*

S. N.	*Phytochemical*	*Andrographis paniculata*			*Swertia chirayita*		
		Aqueous	*Alcohol*	*Petrol. ether*	*Aqueous*	*Alcohol*	*Petrol. ether*
1	Carbohydrate (C)	+ve	+ve	+ve	+ve	+ve	+ve
2	Alkaloids (Al)	+ve	+ve	–ve	+ve	+ve	+ve
3	Proteins (P)	+ve	–ve	–ve	+ve	–ve	–ve
4	Saponin (Sa)	+ve	+ve	–ve	+ve	+ve	–ve
5	Glycosides (Gl)	+ve	–ve	–ve	+ve	–ve	–ve
6	Phenolic compounds (Ph)	+ve	+ve	–ve	–ve	+ve	–ve
7	Steroids (St)	+ve	+ve	+ve	+ve	+ve	+ve
8	Tannin (Ta)	+ve	+ve	–ve	+ve	+ve	–ve
9	Flavonoid (Fl)	+ve	+ve	+ve	+ve	+ve	+ve
10	Terpenoids (Te)	–ve	+ve	+ve	–ve	+ve	+ve

Out of the total ten phytochemicals studied, nine (carbohydrates, alkaloids, proteins, saponins, glycosides, phenolic compounds, steroids, tannins, and flavonoids) were found in *Andrographis paniculata* (aqueous extract) and eight (carbohydrates, alkaloids, proteins, saponins, glycosides, phenolic compounds, steroids, tannins, and flavonoids) in *Swertia chirayita* (aqueous extract) that showed the possibility of broad spectrum activities of *Andrographis paniculata* as compared with *Swertia chirayita*.

Figure 5 Graphical representation of phytochemical analysis in alcohol extract of a. paniculata and s. chirayita (see online version for colours)

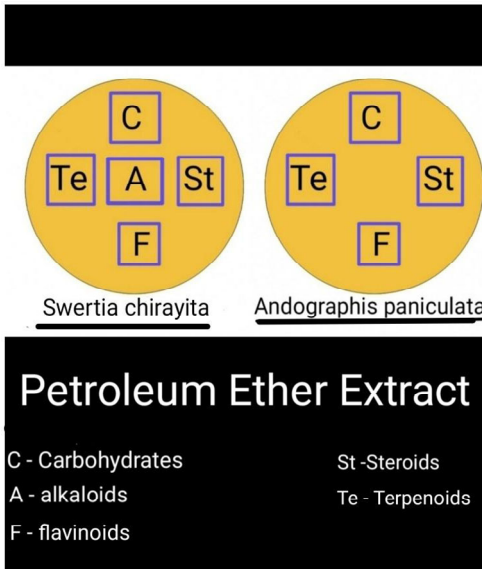


Phytochemicals studied in Alcoholic extracts of the comparative plants show the absence of two major phytochemicals, i.e., proteins and glycosides. Again it shows the similarities between *A.paniculata* and *S.chirayita* (Pl. refer Figure 5).

The last figure gives the data of phytochemicals present in the petroleum ether extracts of *A. paniculata* and *S. chirayita*. The least number of phytochemicals are present in the petrol extracts of the respective plants in comparison to their alcoholic and aqueous extracts. However again the phytochemicals present are similar for both the studied plants except for the absence of alkaloids in *A. paniculata* (Pl. refer Figure 6).

Carbohydrates, steroids, flavonoids, and terpenoids were found in petroleum ether extracts of *Andrographis paniculata* and *Swertia chirayita*. Furthermore, alkaloids were exclusively found in the *Swertia chirayita* extract. Proteins, saponins, glycosides, phenolic compounds, and tannins, on the other hand, were not discovered in extracts.

Figure 6 Graphical representation of phytochemical analysis in petroleum ether extract of a. paniculata and s. chirayita (see online version for colours)



5 Discussion

S. chirayta is an important drug described in *Charak Samhita* with the names *Kiratatikta* and *Bhunimb*. It is indicated in *Jwar chikitsa* (C.S.ci. 3/198, 343), *Raktapitta Chikitsa* (C.S. ci.4/38,45) *Atisar chikitsa* (C.S. ci.19/50, 52), and *Grahni roga* (C.S. ci.15/132–140) (Sharma, 2014). *Acharya Sushruta* classified it under the group of *Tikta skandha*, and *Aragvadhadi Gana* (Shastri, 2019) and indicated it in skin disorders. *Kalmegh* is a popular drug but not described in *Charak* and *Sushruta samhita*. *Kalmegh* is described by Vaidya Bapalal in his book Adarsh Nighantu and by Acharya Priyavrat Sharma in his texts, Priya Nighantu (Sharma, 2004) and Dravyaguna Vigyan. Both are renowned personalities of Ayurvedic pharmacology and Materia medica. On reviewing the Ayurvedic literature it is seen that both drugs have the same Ras panchak or properties and are mostly indicated in similar diseases such as liver disorder, fever, diabetes, skin disorders, etc.

On the basis of physicochemical analysis we find differences between *A. paniculata* and *S. chirayita*; moisture content is lesser in *A. paniculata than S. chirayita*. Moisture content of drugs should be at a minimal level to discourage the growth of bacteria, yeast or fungi during storage. Thus, life expectancy is more of *A. paniculata*. The higher ash value is suggestive of heat-stable or inorganic constituents. Total ash, water soluble ash, and acid insoluble ash were found higher in *Andrographis paniculata* in comparison to *Swertia chirayita*, indicating that the *Andrographis paniculata* contains more minerals.Estimation of extractive values determines the amount of the active constituents in a given amount of plant material when extracted with a particular solvent. The presence of polar chemicals in *Swertia chirayita* indicates its greater alcohol and aqueous extractive values (The Ayurvedic Pharmacopoeia of India, 2008) (Pl. refer Table 6).

On the basis of qualitative phytochemical analysis of Kiratatikta and Kalamegha, it has been observed that maximum phytochemicals are similar like Carbohydrate, Amino acids, Protein, Alkaloids, Glycosides. Tannin and Phenolic compounds are present in both aqueous and alcoholic extract of A. paniculata while present only in alcoholic extract of *Swertia chirayita*.

'Bahuta Tatra Yogyatvam Anek Vidh Kalpna, Sampachiiti Chatushkoayam Dravayanam Guna Uchayte.' (Charak, Sutra, Chapter 9, verses7)

Acharya Charak, a renowned physician , states the quality of a good drug, He says that a drug must have four qualities, i.e., first is *Bahuta* means abundance, drugs or sources of drugs should be in abundance so that it be easily available. Second is *Yogyatvam* means efficiency. A drug must be able to treat the disease without any side effects. Third is *Anekvidh Kalpna* means different formulations. A drug can be used through different formulations such as tablets, syrup, etc. Fourth is *Sampatt,* i.e., quality wise good, A drug should be of good quality, it never be used after it is expiry date (Sharma, 2014)[29].

Kiratatikta, i.e., *Swertia chirayita* is not only very costly but also an endangered species making its availability harder for common use. On the other hand *Kalmegh,* i.e., *A. Paniculata* not only is cheap and cost effective as in the Indian market the price of *Kalmegha* is Rs.120/- per kg as compared to *Chirayta*, which is Rs. 900/- per kg .It can be grown anywhere easily just like a weed making it much more feasible. If *A. Paniculata* is used as a substitute for *Swertia chirayita* then it will be beneficial for both pharmaceuticals as well as the environment. As we know *S. Chirayita* is an endangered species and is available in a narrow zone while *A. Paniculata* is easily available in abundant quantities, thus authentic use of *A. Paniculata* will help to check the exploitation of *S. Chirayita*. Additionally due to its abundance it is cheap so will be economically beneficial for pharmaceuticals and society. Abundance is one of the qualities of a drug among the four, i.e., abundance, affectivity, various pharmaceutical forms and excellence of composition as mentioned in *Charak Samhita*, renowned text of *Ayurveda*.

Nagarjan et al. (2015) also gave significant emphasis on inclusion of some new substitute drugs as *Abhava pratinidhi dravya* (substitute drug) by understanding the concept of *Dravyaguna* to better explore the logic behind selection of substitute drugs. This will be helpful in identifying new substitutes, especially for those drugs that are unavailable due to their regional, seasonal, and endangered status. On the basis of similarities in therapeutic actions, the *Andrographis paniculata* might be considered as a substitute of the *Swertia chirayita* (Girach et al., 1994).

6 Recommendations

In present work, a comparative study has been done to evaluate the similarity and dissimilarity between *Swertia chirayita* (*Kiratatikta*) *and Andrographis paniculata* (*Kalmegh*). This study compares both the drugs on the basis of their phytochemicals, pharmacological actions, ethnomedicinal uses, and therapeutically uses as per *Ayurveda*. This study provides a detailed knowledge of both herbs in the light of Ayurvedic perspective as well as modern research. The authentication and qualitative phytochemical profiles of both drugs were fairly established in this study. On the basis of their similarities in their pharmacological actions, therapeutic actions, and ethnomedicinal

uses, *Kalmegh* might be considered as a substitute for *Kiratikta*, which is not only economically beneficial but can also protect the reckless exploitation of *Kiratatikta*, which is on verge of extinction.

7 Future research directions and limitations

7.1 Future research directions

- There is a need for holistic conservation of both the medicinal plants through the organic cultivation or micropropagation methods.
- The molecular pathways, cellular signalling, and genomic interactions of specific active constituents may be worked out through the application of cheminformatics, proteogenomic, and network pharmacological analysis.
- The synthetic analogs of these active chemical constituents may be further explored for drug-like properties.
- To establish the efficacy of both *S. chirayita* and *A. paniculata*, comparative clinical trials must be performed.

7.2 Limitations

This work did not analyse quantitative data of phytochemicals. In all probability it is pivotal to perform the comparative critical study of S. chirayita and A. paniculata in order to prove their vitality. Comprehensive comparative studies may also be conducted with other species of Acanthaceae and Gentianaceae families.

8 Novelties

- Critical Comparative study of two herbs having almost similar properties.
- The manuscript discusses strengths and limitations for both the herbs.
- The presented work discusses why *A. paniculata* should be used as a substitute for S. chirayita.
- This study has a more practical approach and application which can benefit a common person also.
- Ethically, the manuscript motivates audiences to reduce consumption of Kiratatikta and thus prolonging the extinction.

9 Conclusions

Properties of *Swertia chirayita* and *Andrographis paniculataare* almost similar but there are many dis-similarities too. *Swertia chirayita* is more acidic and has more aqueous and alcoholic solubility as compared to *Andrographis paniculata*. In terms of ash value

Andrographis paniculata is having better results. It may be concluded that we can achieve more bioavailability of the drug with *Swertia chirayita* through aqueous and alcoholic extract as compared to *Andrographic paniculata. Andrographis paniculata* with rich ash value confirms its rich mineral content. *Swertia chirayita* also has the advantage of having alkaloids in petroleum ether extract.

The phytochemical profiles of both drugs have been fairly established in this study, and it was found that *A. paniculata* had a higher amount of phytochemicals and higher ash values (total ash, water soluble ash, and acid insoluble ash), indicating the presence of more mineral content than S. chirayita. The study showed a number of similarities between both herbs in regarding of their pharmacological activities and therapeutic uses. As a result, it is possible that *Andrographis paniculata* could be utilised as a substitute for *Swertia chirayita*.

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Annexures

Key terms and definitions

- Swertia chirata – Swertia chirata is a bitter tonic, carminative, laxative, antipyretic, febrifuge, anti-periodic, anti-inflammatory, stomachic, and anthelmintic. It is used in treating piles, skin diseases, ulcers, and diabetes.
- Kiratikta – Sanskrit name for Swertia Chirata as used in Ayurveda classics.
- Andrographis paniculata – Andrographis paniculata is used in traditional medicine to treat infectious diseases and fevers. Andrographis exhibits antibacterial, antioxidant, anti-inflammatory, anticancer, and immunostimulating properties.
- Kalmegha – Kalmegh is a plant which is also known as ‘Green Chiretta’ and the ‘King of Bitters’. It is used for various medicinal purposes and is bitter in taste. It is mainly used for liver problems as it protects the liver against damage caused by free radicals due to its antioxidant and anti-inflammatory activity.
- Bhunimba – Bhunimba is a bitter-tasting herb that is popular amongst practitioners of Ayurveda, Traditional Chinese Medicine, and western herbology. Indian herbalists often refer to it as the ‘King of Bitter herbs. ‘ It serves as a natural supplement to support the immune system and removal of toxins from the blood.
- Ayurveda – Ayurvedic medicine is one of the world’s oldest holistic healing systems. It was developed more than 3,000 years ago in India.It is based on the belief that health and wellness depend on a delicate balance between the mind, body, and spirit. Its main goal is to promote good health, not fight disease. But treatments may be geared toward specific health problems.

Additional readings

- Current update of Ayurvedic drugs used in fever: a critical review
  https://www.researchgate.net/publication/304908076_CURRENT_UPDATE_OF_AYURVEDIC_DRUGS_USED_IN_FEVER_A_CRITICAL_REVIEW
- Traditional Herbal Remedies for Primary Healthcare
  https://apps.who.int/iris/bitstream/handle/10665/206024/B4572.pdf?sequence=1
- Validation and quantification of major biomarkers in ‘Mahasudarshan Churna’- an ayurvedic polyherbal formulation through high-performance thin-layer chromatography
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7291524/

- Introduction and Importance of Medicinal Plants and Herbs
  http://nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
- Pharmacognostical and TLC Fingerprinting of Andrographis Paniculata (Kalmegh)
  https://www.researchgate.net/publication/340526769_Pharmacognostical_TLC_Fingerprinting_of_Andrographis_Paniculata_Kalmegh

Supported Picture/ snapshot lab

Figure A1 Andrographis paniculata (see online version for colours)

Source: https://images.app.goo.gl/ed7vb3pwlfx6cqpw7)

Figure A2 Sample of andrographis paniculata as raw medicine (see online version for colours)

Source: https://images.app.goo.gl/f3xhubr6qfned54t8.

Figure A3 Field survey and sample collection of A.paniculata (see online version for colours)

Figure A4 (a) Herbarium sheet of A.paniculata (b) Swertia chirayita (see online version for colours)

Figure A5 Swertia chirata as raw medicinal herb (see online version for colours)

Source: https://images.app.goo.gl/fwujcehgly8jrldt5)

Figure A6 (a) Field survey and sample collection of swertia chirayita (b) herbarium sheet of S.chirayita (see online version for colours)